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REACTION WHEEL UNLOADING USING EXTERNAL TORQUE FOR VARIABLE SHAPE SPACECRAFT

Abstract

Variable Shape Attitude Control (VSAC) is an attitude control method using by actively changing the shape and mass distribution of the satellite, such as by driving the solar array paddles, for example. Past research works have shown that this attitude control method can provide high agility maneuver and, in addition, high accuracy and stability in conjunction with reaction wheels which are well-used tools for the attitude control. Thus it is expected that the variable shape system with reaction wheels will be a promising combination for high performance attitude control of the satellite. On the other hand, the reaction wheel has the saturation problem which degrades attitude control performance when the rotation speed reaches the upper limit of the reaction wheels.

In this paper, we focus on the desaturation or unloading method of the reaction wheel using the variable shape function. Considering that there is a feature of the variable shape system, namely, the ability to change the direction and magnitude of external torque acting on the satellite such as atmospheric drag torque and gravity gradient torque, we propose a method to desaturate the reaction wheel speed with the external torque control using the variable shape system.

In this study, as an example of a variable shape spacecraft, we use a model of the 50 kg class satellite named by HIBARI launched into a Low Earth Orbit with JAXA's Epsilon rocket No. 5 in November 2021. We analyze how the change of the satellite shape can control the external torques: both the atmospheric drag torque and the gravity gradient torque, and show that a specific paddle angle range is found in order to efficiently unload the reaction wheel speed. Next, we verify by numerical simulations that the reaction wheel can be unloaded by driving the paddle to the specified position and controlling the reaction wheel to maintain the satellite attitude against the external torques.

The feature of this method is that by controlling paddle position, the reaction wheel can be unloaded while the attitude pointing can be maintained in the desired direction. Currently, we are planning to conduct an in-orbit unloading experiment using the HIBARI satellite.